

PEEM Image Analyzer

Workbench.sav

Version 1.023

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Introduction

Foreword

The program has been developed for the analysis of Photoemission Electron Microscopy (PEEM) data, in particular for magnetic microscopy. The program reads data stored in TIF (including the Advanced Light Source, ALS PEEM-2 12bit format), the Swiss Light Source PNG format, the ALS STXM XIM format (a header-less ASCII format), the ALS streak camera LVB format (a binary format, written in Labview), and the Roper Scientific SPE format.

The nature of such programs is that they are never finished and are therefore permanently in an alpha stage. Unexpected errors may appear if the program is used in ways that were not anticipated by the developer. New functions will be added if the need arises, and new versions will be posted on the PEEM-2 web page:

<http://xraysweb.lbl.gov/peem2/PEEM2-02.html>

The program is written using object-oriented methods, and the source code can be obtained upon request.

Andreas Scholl

System Requirements

Recommended:

P4 at 2 GHz

1 GB RAM

20 GB HD space

Tested with Windows 2000.

Requires the Research Systems IDL Virtual Machine 6.2 or an IDL 6.2 development license.

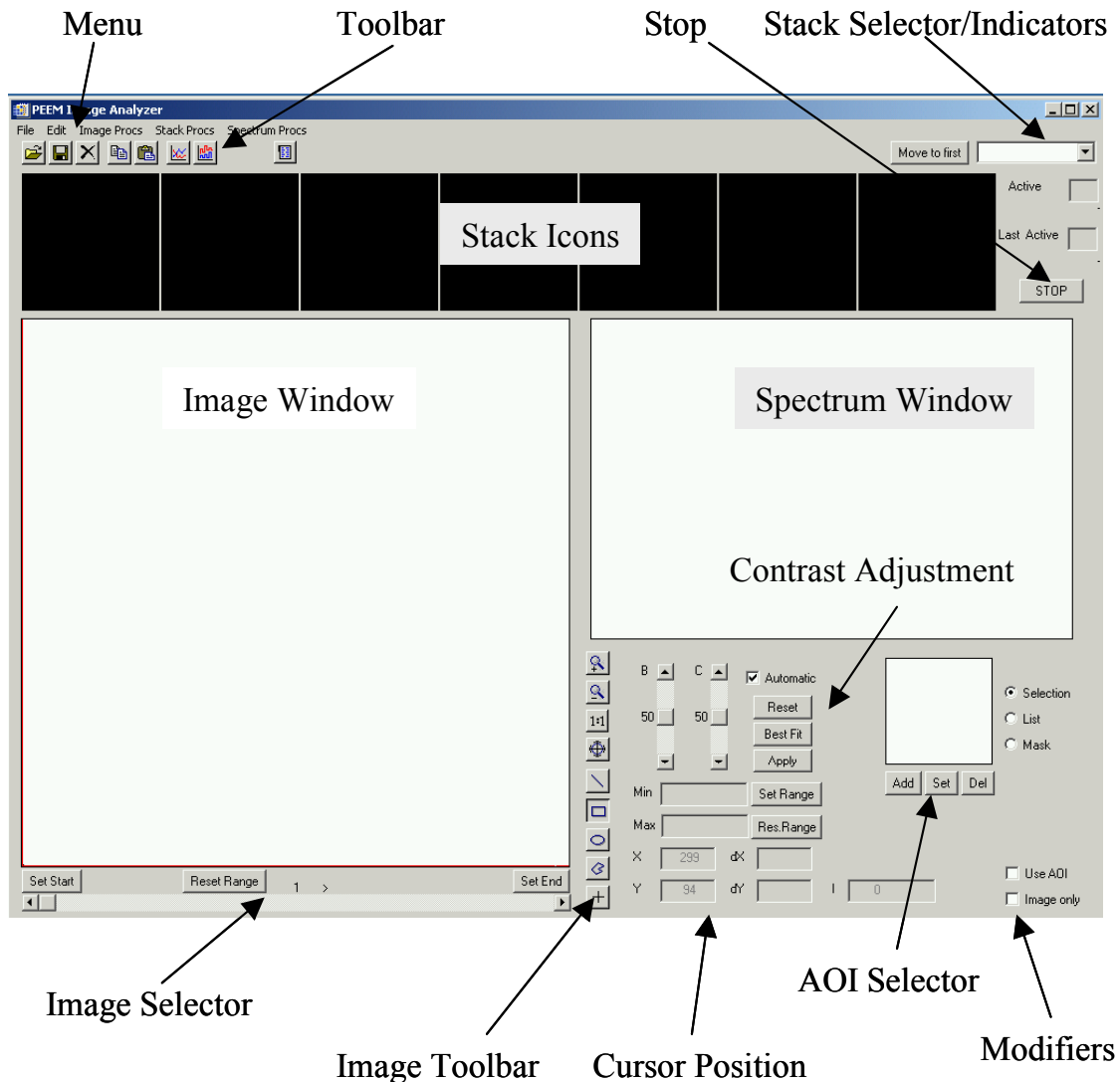
Installation

Install the IDL development system or the IDL Virtual Machine 6.0. Refer to the IDL documentation for help with the installation. Copy Workbench.sav and all *.bmp files into a folder. Start the program by double-clicking Workbench.sav. Opening Workbench.sav with the Virtual Machine “Load File” dialog box breaks the links to some bitmaps and buttons. Therefore always start the program by double-clicking Workbench.sav in a Windows folder. The Virtual Machine will be started automatically.

User Interface

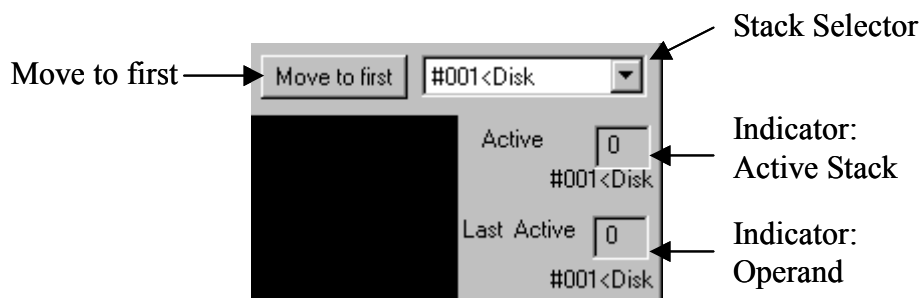
Components

The main components of the user interface are the image window, the spectrum window, and the list of stack icons. Other components are the menu bar, tool bars, the stack selector list, the area of interest (AOI) list, contrast adjustment functions, and status indicators. Pressing the “STOP” button will interrupt a running process.



Stack Icons

The list of stack icons previews up to 7 stacks at the same time. A left-click on an icon selects the stack for display in the image window. A right-click on an icon displays status information. When you open a multi-image stack, the first image is shown automatically scaled. When you step through the currently active stack using the image selector slider (see *Image Window*), the stack icon is also updated.



The icon list operates like a memory stack. New images are added to the far left while older images slide to the right. Only the 7 most recent stacks are displayed. Other stacks shift out of view but are still in memory. They can be brought back into view using the Stack Selector tool. The number of open stacks is currently limited to 20 to prevent memory overflows. If stacks beyond that limit are opened, stack 20 will be closed every time a new stack is opened.

The Stack Selector drop list displays all opened stacks using the following naming convention: The displayed name is a combination of the file name, if the file originated from disk, or the name of the operation that generated the stack, and, after a “<” character, the parent of the stack. The parent can be “Disk” or the name or names of the stacks that were used to create the current stack. These names are not necessarily unique, in particular for temporary stacks. Internally all stacks have unique names that can be viewed by right-clicking on a stack icon.

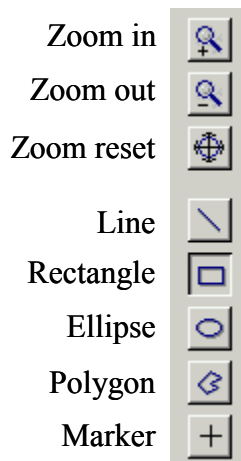
The “Move to first” button moves the stack selected in the drop list to the first (left-most) position in the icon list. The Active indicator specifies the currently selected stack. This is the stack that was most recently selected by left-clicking on its icon or by using the “Move to first” button. The Last Active indicator specifies the stack that was active last before a new stack was selected. Operations that require 2 images use the Active stack as the 1st operand and the Last Active as the 2nd operand.

Image Window

The image window displays one image of a stack. A stack is a series of images that can be manipulated as a single entity. The image selector slider below the image window is used to step through a multi-image stack and to select a particular image of the stack. The 2 numbers above the image selector specify the image number (left) and the photon energy at which the image was acquired (right)¹.

A double-click of the left mouse button on the image calculates the energy spectrum at the cursor position. The result is displayed in the spectrum window.

¹ A data file including an energy column has to be loaded first using the “Attach” function.



The icons to the right of the image window allow you to zoom and to select areas in the image. The status bar at the bottom right of the user interface shows the cursor position and the displacement since the last mouse click.

The “Zoom in” function magnifies the image to show the area selected by the Rectangle, Ellipse, or Polygon tools. The “Zoom out” function demagnifies the image by a factor of 2. The “Zoom reset” function resets the zoom to 1 so that the whole image is shown. Note that images that have an aspect ratio different from 1 are shown distorted.

The Line tool allows you to draw a line, which can then be used in the Line Profile function. Two sequential clicks of the left mouse button set the starting point and the end point of the line.

The Rectangle tool draws a rectangular box, which can then be used as the area of interest (AOI) by many functions, e.g., the Calc Spectra function. Two sequential clicks of the left mouse button define two opposite corners of the rectangle. An already defined rectangular AOI can be moved by first defining the new location of one corner with a left-click, and then right-clicking².

The Ellipse tool draws an elliptical AOI. Two sequential clicks of the left mouse button define the rectangle that encloses the ellipse.

The Polygon tool draws a polygonal AOI. Sequential clicks of the left mouse button define the corners of the polygon. A right-click concludes the definition and closes the polygon.

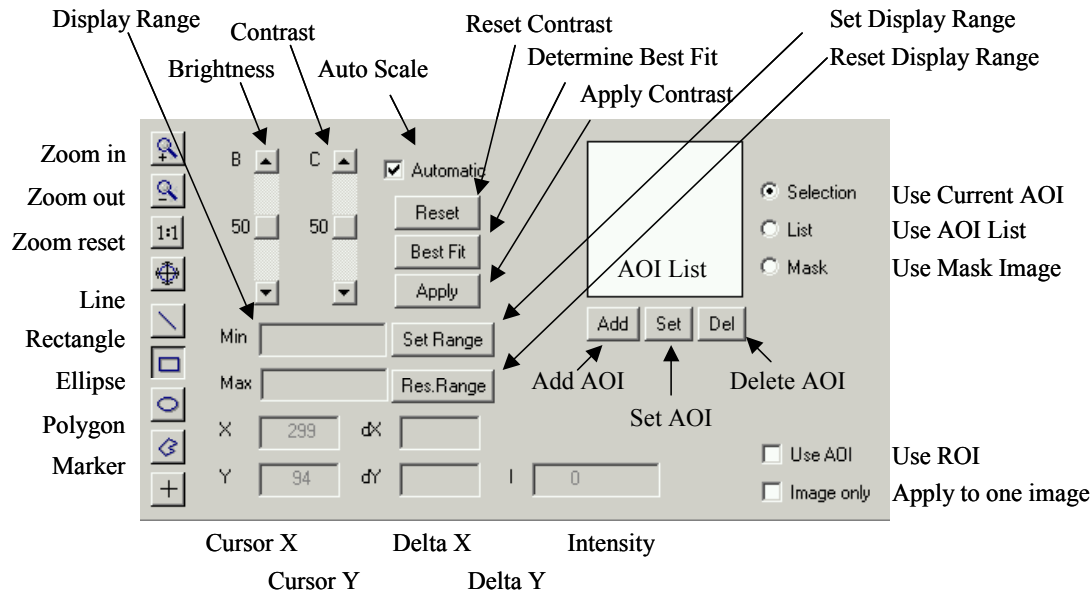
Lines and AOIs (rectangles, ellipses, polygons) are identical in all images of a stack.

The Marker tool is used by the Mark Align function. In contrast to lines and AOIs, markers are set individually, image by image. A left-click of the mouse positions the marker in the currently selected image of the stack. This does not affect marker positions in the other images.

Spectrum Window

The spectrum window displays energy spectra, image histograms, and line profiles. If the spectrum is an energy spectrum, a left-click within the spectrum window displays the image in the image window that corresponds to the selected data point or photon energy. A right-click on the spectrum window opens a dialog box to adjust the x and y scales.

² Only recently drawn boxes can be moved. Boxes that were copied from the AOI list cannot be displaced by this method.



Controls and Indicators

The zoom and area tools on the left side of the Controls and Indicators panel set the viewing area, the area of interest, lines, and markers in the image window.

The sliders and buttons in the top center of the Controls and Indicators panel specify the brightness and contrast settings of the image window. The Automatic checkbox toggles between automatic image scaling and manual scaling using the slider controls. If Automatic is set, then each image displayed in the image window is scaled optimally. This means that the intensity of all pixels lies within the display range of the screen. The automatic scaling function can be fooled by hot pixels that are significantly brighter than the rest of the image. The automatic scaling also changes from image to image in a stack, making it difficult to evaluate the actual intensity of the image.

If Automatic is not set, each stack possesses individual manual brightness and contrast settings that apply to all images in the stack. The brightness and contrast slider controls range from 0 to 100%. Higher numbers mean increased brightness and contrast. Changing the display contrast does not affect the stack data itself. The Reset button resets contrast and brightness to 50%, which means that the full image range, e.g., 0 – 65535 in a 16-bit image, is mapped onto the display range of the output device. The image range can be modified using the “Set Range” and “Res. Range” buttons. The Best Fit button determines and sets the optimal brightness and contrast for the displayed image and applies it to all images in the stack as you step through the stack. The Apply button creates a scaled duplicate of the original stack using the current contrast and brightness settings. The new image stack always has 8-bit depth. The Use AOI and “Image only” checkboxes apply.

Multiple areas of interest (AOIs) are stored in the AOI List box. This box can contain up to 20 different AOIs, labeled 0 – 19. An AOI is added to the list by pushing the Add button. An AOI is copied from the list to the active image by first selecting an AOI in the list and then pushing the Set button or by double-clicking its number. The radio buttons Selection, List, and Mask determine which areas are used to calculate spectra. Choosing Selection means that a single spectrum is calculated from the current AOI defined in the image window. Choosing List calculates multiple spectra using the AOIs stored in the AOI List. Choosing Mask lets the program use the Last Active image as a mask image. A single spectrum is calculated from all pixels that are non-zero in the mask image.

The status bar at the bottom of the Controls and Indicators panel shows the current cursor position and its relative displacement since the last mouse click.

The Use AOI checkbox specifies whether a stack or image operation is applied to the whole image or to the current AOI only. This checkbox applies to the menu functions Duplicate, Combine, Rotate, Histogram, Filters..., Smooth, and Median and to the Apply button.

The “Image only” checkbox specifies whether a stack or image operation is applied to the whole stack or only to the currently active image. This checkbox applies to the menu functions Duplicate, Combine, Resize, Rotate, Line Profile, Horz. Profile, Vert. Profile, Histogram, Filters..., Smooth, and Median and to the Apply button.

Menu

Warning: The program will produce unexpected results or may even crash if two stacks of different image sizes or types are combined or if a binary arithmetical or logical operation is carried out on them!

File

The file menu contains input/output functions.

Load

Loads an image or a stack from disk. A stack can be loaded either from a multiple image file or from a selection of files. Single image files and multiple image files can be mixed. The image type, image dimension, and bit depth must be the same for all images. Currently, only the TIFF type is supported. The function should be able to correctly read 8-bit, 16-bit, and 32-bit gray-scale TIFF. Multiple images are selected using the standard CNTR+Mouse-click and SHIFT+Mouse-click procedures³. CNTR+A selects all images in a folder.

Save As

Saves the stack to disk as a multiple image file. Currently, only the TIFF type is supported. The function should correctly write 8-bit, 16-bit, 32-bit and single precision floating -point TIFF.

Export Tiff

Saves a stack as multiple single image TIFF files. The images are enumerated Filename#XXXX.tif with XXXX a 4 digit number starting at 0000.

Export Binary

Saves a stack as multiple single image binary files. The images are enumerated Filename#XXXX.dat with XXXX a 4 digit number starting at 0000.

Export Ascii

Saves a stack as multiple single image text files. The images are enumerated Filename#XXXX.txt with XXXX a 4 digit number starting at 0000.

Close

Closes the current stack.

Close All

Closes all stacks.

³ Images have to be selected starting with the end of the stack to make sure that they are opened in the correct order.

Attach Energy/I0

Reads an energy/I0 data file associated with an image stack. A spectrum must be calculated before a file can be attached

Save Spectrum

Saves spectra associated with an image stack.

Load AOI

Loads a previously saved AOI list.

Save AOI

Saves an AOI list.

Exit

Closes the program. Asks user whether to save unsaved stacks and images.

About...

About this program.

Edit

The edit menu contains image-copying and transformation functions.

Copy

Copies an image to the clipboard

Paste

NA

Duplicate

Duplicates an image or stack. The function uses the current AOI if the Use AOI checkbox is checked. It duplicates only the currently displayed image out of a multi-image stack if the "Image only" checkbox is checked.

Convert

Converts a stack into a different length TIFF format. Currently 8-bit, 16-bit, 32-bit and single precision floating-point are available. The function uses the current AOI if the Use AOI checkbox is checked. It converts only the currently displayed image out of a multi-image stack if the "Image only" checkbox is checked.

Explode

Explodes an image stack into single images. The number of free spaces in the stack list limits the length of the stack that can be exploded.

Combine

Combines two stacks into a single stack. This function uses the current AOI if the Use AOI checkbox is checked. It combines single images of the two stacks if the “Image only” checkbox is checked. The image size and pixel depth in both stacks must be equal. The image size may be different if the Use AOI box is checked and the current AOI is within the boundaries of both source stacks.

Rebin

Opens a dialog box for re-binning an image or stack. In contrast to the “Resize” function “Rebin” does not simply resample the image. Instead it will group and average pixels in the image if the image is deflated in size and it will interpolate if the image is expanded in size. Orphaned pixels at the image boundary will be discarded. This function will re-bin a single image if the “Image only” checkbox is checked.

Resize

Opens a dialog box for resizing an image or stack. This function will resize a single image if the “Image only” checkbox is checked.

Rotate

Opens a dialog box for rotating a stack. Use the Line tool to indicate the line The angle displayed is the slope of the line drawn with the Line tool. A structure aligned with this line will be horizontal after the rotation. The image size is kept constant. Alternatively, fixed angle rotation and mirror operations can be selected. The 90° and 270° rotations exchange the horizontal and vertical image dimensions. This function uses the current AOI if the Use AOI checkbox is checked. It rotates a single image if the “Image only” checkbox is checked.

Delete Marker

Deletes the mark indicator in the current image.

Delete All Markers

Deletes all markers.

Set Box

Define the boundaries of a rectangular box by their coordinates.

Image Procs

The image operations menu contains functions that primarily manipulate single images. These functions can also be applied image-by-image to a stack.

Line Profile

Calculates a line profile and displays it in the spectrum window. The line is defined by the Line tool. If “Image only” is not selected, the function creates a line profile for each image of the stack.

Horiz. Profile

Calculates an intensity profile in a rectangular area and displays it in the spectrum window. The area is defined by the “Rectangle tool”. The width of the rectangle determines the length of the profile. The height determines the length over which pixels are averaged. If “Image only” is not selected, the function creates a line profile for each image of the stack.

Vert. Profile

Calculates an intensity profile in a rectangular area and displays it in the spectrum window. The area is defined by the “Rectangle tool”. The height of the rectangle determines the length of the profile. The width determines the length over which pixels are averaged. If “Image only” is not selected, the function creates a line profile for each image of the stack.

Normalize to Horiz.

A horizontal profile is calculated over the whole image if “Use AOI” is not selected, or over a rectangular area, stretching from the left of the image to the right and limited in height by the height of the current AOI. This line profile is then used to scale the image intensity column-by-column. Note that this routine only works properly for floating point images. If “Image only” is not selected, the function renormalizes each image of a stack.

Normalize to Vert.

A vertical profile is calculated over the whole image if “Use AOI” is not selected, or over a rectangular area, stretching from the top of the image to the bottom and limited in width by the width of the current AOI. This line profile is then used to scale the image intensity row-by-row. Note that this routine only works properly for floating point images. If “Image only” is not selected, the function renormalizes each image of a stack.

Histogram

Calculates the histogram within a rectangular area. If Use AOI is selected, then the area is defined either by the Rectangle tool or by the smallest box that encloses the selected ellipse or polygon areas. If Use AOI is not selected, then a histogram of the whole image is calculated. If “Image only” is not selected, this function displays a histogram for each image of a stack.

PoweSpectrum

Calculates a one-dimensional power spectrum of the Fourier transform of an image or a stack.

Operations...

Performs an arithmetic or logic operation on one or two stacks. A dialog box is opened to set parameters and perform operations (see *Operations Dialog Box*). The Operations... dialog box cannot be opened when the Filter... dialog box is in use.

Filters...

Opens the dialog box for applying filters. Currently, two standard IDL filters are available: Smooth and Median. The dialog box that opens is not modal. Stacks can be selected by left-clicking on a stack in the icon list. Alternatively, the stack can be selected using the drop list in the dialog box. The parameters Width and Repeat specify the coarseness of the filter and the number of filter iterations. Filter operations are time consuming! The filter is applied only to the current AOI if the Use AOI checkbox is selected. In contrast to other functions, the image size is not changed. If “Image only” is selected, the function applies the filter to the current image only. The Filter... dialog box cannot be opened when the Operations... dialog box is in use.

Smooth

Applies a Smooth filter with radius 3 to the current stack. The filter is applied only to the current AOI if the Use AOI checkbox is selected. In contrast to other functions, the image size is not changed. If “Image only” is selected, the function applies the filter to the current image only.

Median

Applies a Median filter with radius 3 to the current stack. The filter is applied only to the current AOI if the Use AOI checkbox is selected. In contrast to other functions, the image size is not changed. If “Image only” is selected, the function applies the filter to the current image only.

Correlate

Calculates the cross correlation factor (-1...1) between the currently selected images of 2 stacks. A dialog box shows the result.

Stack Procs

The stack operations menu contains functions that can only be applied to multiple image stacks.

Calc Spectra

Calculates spectra from one or multiple areas of a stack. The Selection/List/Mask radio buttons determine the area that is used. Choosing Selection means that a single spectrum is calculated from the current AOI defined in the image window. Choosing List calculates multiple spectra using the AOIs stored in the AOI List. Choosing Mask lets the program use the Last Active image as a mask image. A single spectrum is calculated from all pixels that are non-zero in the mask image. The result is displayed in the spectrum window and can be saved using Save Spectrum in the File menu. To obtain a correct energy axis in the spectrum, an energy axis must first be attached to the stack using Attach Energy/I0 in the File menu. The I0 data in the attached file is currently ignored. An image is automatically copied to the clipboard that shows the outlines of all AOIs in color. This picture can be used to document the spectrum analysis.

Sort (ABAB)

Averages all odd and all even images of a stack and generates a stack containing the two averaged images. For further operations the resulting stack can be exploded into individual images using the Explode function the Edit menu. It is not essential that the number of stack images be even.

Sort...

Sorts and averages stacks using a sort pattern defined in a dialog box. “# Elements” specifies the number of distinct elements in the pattern. For example, the following pattern has three elements: AABBBCCAABBCC. Block Size specifies the size of a block of similar images. For example, the following pattern has blocks of 2: AABBBCCAABBCC. The “ABCCBA Pattern” checkbox reverses the order of elements in every 2nd block.

Align

Automatically aligns a stack using a search algorithm based on maximizing the cross-correlation function between the first image and the other images of a stack. A rectangular AOI has to be selected in the first stack image. The AOI should enclose a strong feature that appears with similar contrast in all images. The algorithm may fail if the contrast is too weak or the motion between images is too large. If this is the case, use Mark Align. Alignment is time consuming: choosing a small AOIs will improve the speed of the function.

Mark Align

Aligns a stack using markers placed in the images of the stack with the Mark tool. This function shifts all images such that the alignment markers fall on top of each other. If an image does not contain a marker, the function linearly interpolates between the closest marker positions. Markers must be set in the first and the last image of a stack.

Spectrum Procs

Spectrum to Image

Creates an image from a series of spectra by transferring the intensity of each spectrum into a row of the image.

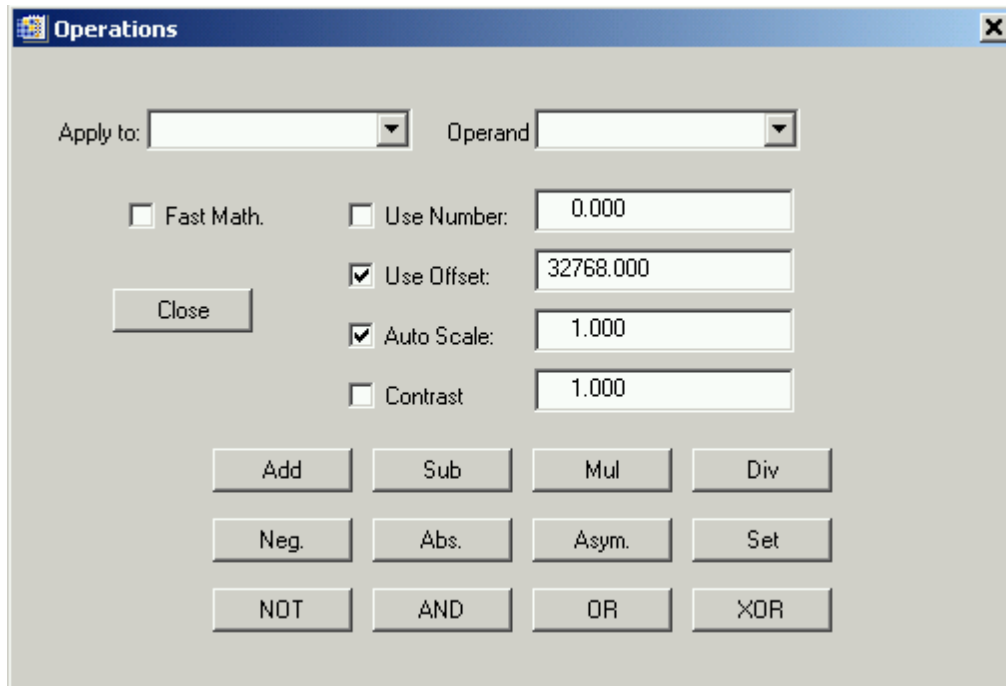
Scan Horizontal

Creates a spectrum from each row of an image.

Scan Vertical

Creates a spectrum from each column of an image.

Operations Dialog Box



Operations in the Operations dialog box can be performed on either 1-image stacks or multi-image stacks. Binary operations can be performed on 2 single images or 2 stacks with the same number of images. The routines also work on a stack with multiple images and a stack containing a single image. The 2 operands are selected using the drop lists in the dialog box or by left-clicking the stack icons. The images have to be of the same size and type.

The 2nd operand can be a number instead of a stack. Select the Use Number box, and the stack operand will be ignored. The operations are then carried out treating the number as an image with constant intensity.

If the Fast Math checkbox is selected, all operations directly use the image data without any offset, scaling, or contrast manipulations. This can lead to over- or underflow problems with integer images. It is recommended to uncheck Fast Math and use the Offset value to avoid over- and underflows.

The following calculations are performed before a binary image operation:

I1, I2: Images are cast to floating point before operation and cast back to original type afterwards.

Scale: Scale is set by $\text{avg}(I2)/\text{avg}(I1)$ if Auto Scale is checked, otherwise scale is set by the value in the Auto Scale text box, (default: 1).

Offset: Offset is set in the Use Offset text box. The default is 32768, which is ideal for 16-bit TIFF. For 12-bit, use 2048; for 8-bit, use 128.

Some examples of binary operations:

Add: $I1 * scale + I2 - offset$

Sub: $I1 * scale - I2 + offset$

Mul: $I1 * scale * I2 / offset$

Div: $I1 * scale / I2 * offset$

Asym: $((I1 * scale - I2) / (I1 * scale + I2) + 1.0) * offset$

If the contrast enhancement checkbox is checked, then the operation below is carried out after the binary operation to enhance the contrast. The effect is not always obvious in the displayed images when the images are optimally scaled in the image window using the Auto Scale checkbox of the user interface.

I: The result of the operation.

Contrast: Enhancement factor.

Offset: As above.

$(I - offset * (1D0 - 1D0 / contrast)) * contrast$